The Green Neighborhood:

Sustainable Family Housing Design

The US Construction Industry

- 1997 estimated value of all U.S. construction is $977 billion.
- Compared to the $7.9 trillion U.S. gross domestic product (GDP), all construction holds a 12% share.
- In 1997, residential and commercial building renovation (valued at $218 billion) and new building construction (valued at $420 billion) is estimated to account for just over 70% (or around $690 billion, including an additional $52 billion for non-contract work) of the $977 billion.

The Built Environment

- A significant impact on available natural resources
- Globally, the building industry consumes
  - 40% of the raw stone, gravel, and sand
  - 25% of the virgin timber
- In the United States, buildings consume
  - 31% of the total energy expended each year
  - 50% of the SO_2
  - 25% of the NO_x
  - 35% of the CO_2 produced
  - $ 210 billion for energy each year
    - $120 billion for residential
    - $90 billion for commercial buildings
  - 28% publicly held and 78% of the buildings privately held

There are more than 76 million residential buildings and nearly 5 million commercial buildings in the U.S. today

Another 38 million buildings are expected to be constructed by 2010 (doe)

The challenge will be to build them intelligently, so that they use a minimum of nonrenewable energy, produce a minimum of pollution and wastes, and cost a minimum of energy dollars, while increasing

Residential Energy Intensities

Type	Per SF (10^3 Btu)	Household (10^6 Btu)	Household/person (10^6 Btu)	Percent Total
Single-Family:	**52.0**	**118.5**	**43.0**	**79.1%**
- Detached	52.0	121.2	43.0	72.1%
- Attached	53.0	96.3	37.0	7.0%
Multi-Family:	**69.0**	**67.3**	**31.0**	**16.3%**
- 2 to 4 units	83.0	99.5	32.0	8.0%
- 5 or more units	60.0	51.5	41.0	8.3%
Mobile Homes	**84.0**	**81.9**	**26.0**	**4.6%**
				100.0%

US Energy Consumption

	% of Total
Residential space heating	9.6
water heating	2.9
refrigerators	1.6
AC	1.3
lighting	1.1
cooking	0.8
dryers	0.5
"other"	1
Residential Subtotal	**19**
Commercial space heating	5.7
lighting	4.4
AC	2.2
refrigerators	1.2
water heating	0.8
cooking	0.2
Commercial Subtotal	**16**

Asphalt	1.7
Process steam	14.6
Electric Drive	8.7
Direct heat	9.5
Feedstocks	5.3
Electrolytic processes	1.3
Indus. "other"	0.4
Industrial Subtotal	**40**
Autos	13.1
Trucks	5.2
Pipelines	2.4
Airplanes	1.7
Rail	0.8
Ships	0.3
Buses	0.2
Trans. "other"	1.5
Transportation Subtotal	**25**

Residential Component Loads

Loads (quads) and Percent of Total Loads				
Component	Heating		Cooling	
Roof	-0.65	12%	0.16	14%
Walls	-1.00	19%	0.11	10%
Foundation	-0.76	15%	-0.07	-
Infiltration	-1.47	28%	0.19	16%
Windows (conductio	-1.34	26%	0.01	1%
Windows (solar gain	0.43	-	0.37	32%
Internal Gains	0.79	-	0.31	27%

Residential Materials

Materials Used in Construction of a 2,085sf Single-Family Home (NAHB 1995)

- 13,127 board-feet of lumber
- 6,212 square feet of sheathing
- 14 tons of concrete
- 2,325 square feet of exterior siding
- 3,100 square feet of roofing material
- 3,061 square feet of insulation
- 6,144 square feet of interior wall
- 2,100 square feet of interior ceiling
- 120 linear feet of duct
- 15 windows
- 5 exterior doors (4 hinged, 1 sliding)
- 2,085 square feet of flooring
- 12 interior doors
- 7 closet doors
- 2 garage doors
- 1 fireplace
- 3 toilets; 2 bathtubs; 1 shower stall
- 3 bathroom sinks
- 13 kitchen cabinets; 2 other cabs
- 1 kitchen sink
- 1 range / hood; 1 refrigerator; 1 dishwasher; 1 garbage disp
- 1 washer; 1 dryer
- 1 heating and cooling system

Residential Construction Waste

	Weight		Volume
Material	pounds	percent	cu. yd.)
Solid sawn wood	1,600	20%	6
Engineered wood	1,400	18%	5
Drywall	2,000	25%	6
Cardboard (OCC)	600	8%	20
Metals	150	2%	1
Vinyl (PVC) (3)	150	2%	1
Masonry (4)	1,000	13%	1
Hazardous Materials	50	1%	-
Other	1,050	13%	11
Total	8,000	100%	50

Residential Building Costs

	Cost	Percent
Finished Lot	53,516	24%
Construction Cost	124,276	55%
Financing	4,266	2%
Overhead & General Expenses	12,955	6%
Marketing	3,180	1%
Sales Commission	7,650	3%
Profit	20,837	9%
Total	226,680	100%

Construction Cost	Cost	Percent
Inspection/Fees	3,497	3%
Shell/Frame	86,168	69%
Equipment	20,064	16%
Property Features	14,547	12%
Total	124,276	100%

Green Development Costs

Green development approaches reduce the need for additional infrastructure.

- the total cost to serve low-density sprawl development
  - three dwelling units/acre is more than $39,600 (1992 dollars) per unit (Chesapeake Bay Program, 1993).
- this cost would increase with distance.
  - if the unit was 10 miles from facilities or major employment centers, the cost would increase an additional $16,500.
- decreasing density also increases cost.
  - one dwelling unit per 4 acres, capital cost per unit increases to $87,700 contiguous
  - $104,000 if located at the 10 mile distance.

Green Neighborhood Objectives

- Improve Quality-of-Life
  - Family satisfaction
  - Soldier retention
  - Safety
- Life-Cycle Costs
  - Energy and water efficiency
  - Maintenance & ‘city services’
- Reduce Negative Environmental Impact
  - Integrate development with nature
  - Material selection
  - Embodied energy/recycled content

What is a Green Neighborhood?

basic tenets of sustainability

- It uses water, energy and other resources efficiently
- It enhances human health
- It strengthens local economies
- It protects cultural, agricultural and natural resources
- It is economical to build and operate

Green Development

an integrated design approach

Process

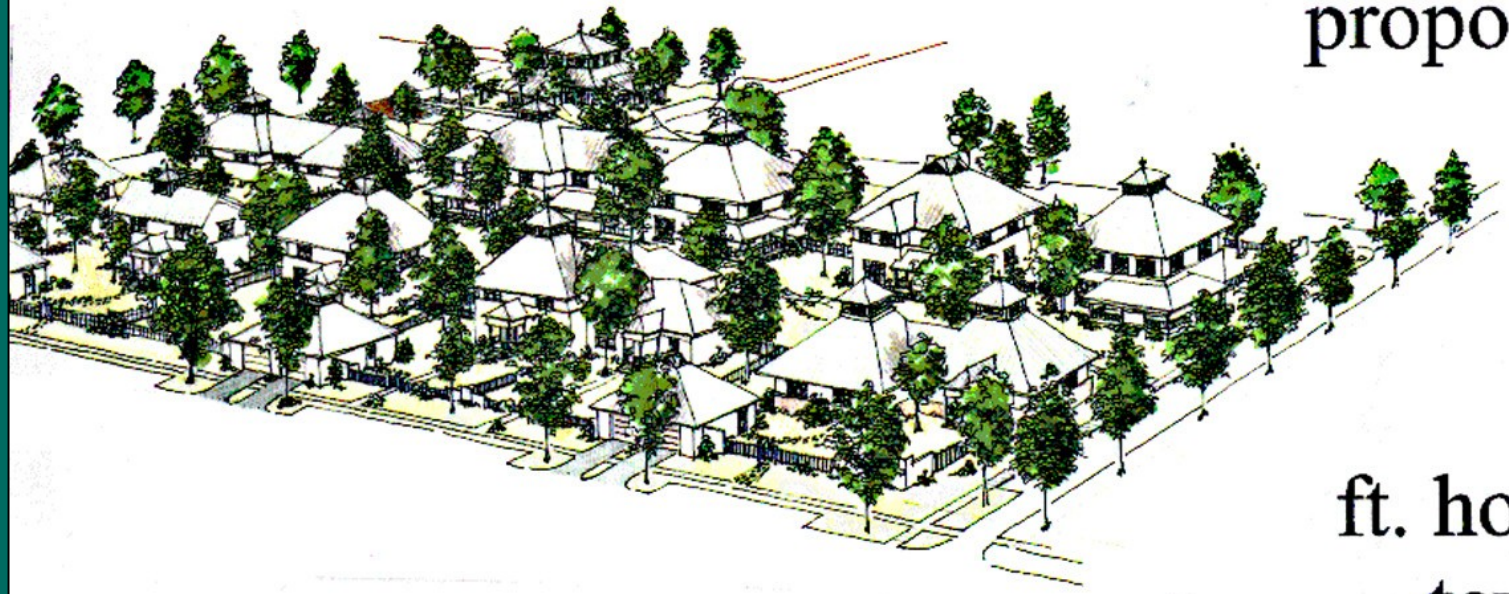
- Multidisciplinary Design Team Approach
  - Architects
  - Landscape Architects
  - Urban Planners
  - Mechanical Engineers
  - Electrical, Civil and Environmental Engineers
  - Residents
    - Focus Groups
- Site-Specific Design
  - Climate specific design
  - Existing terrains and site characteristics to remain
  - Regional vernacular architecture

Site-Specific Design

Examples

- Location: Fort Hood, TX
  - 150 units/ 4-5 bedroom (Junior NCO)
  - Cooling dominated climate
    - DoE/EPA/DoD cool communities initiative
- Location: US Military Academy at West Point
  - 77 units/ 3,4 & 5 bedroom (enlisted - NCO)
  - Heating dominated climate
- Site Selection
  - Infill area
  - Existing land use practices

a green neighborhood proposal



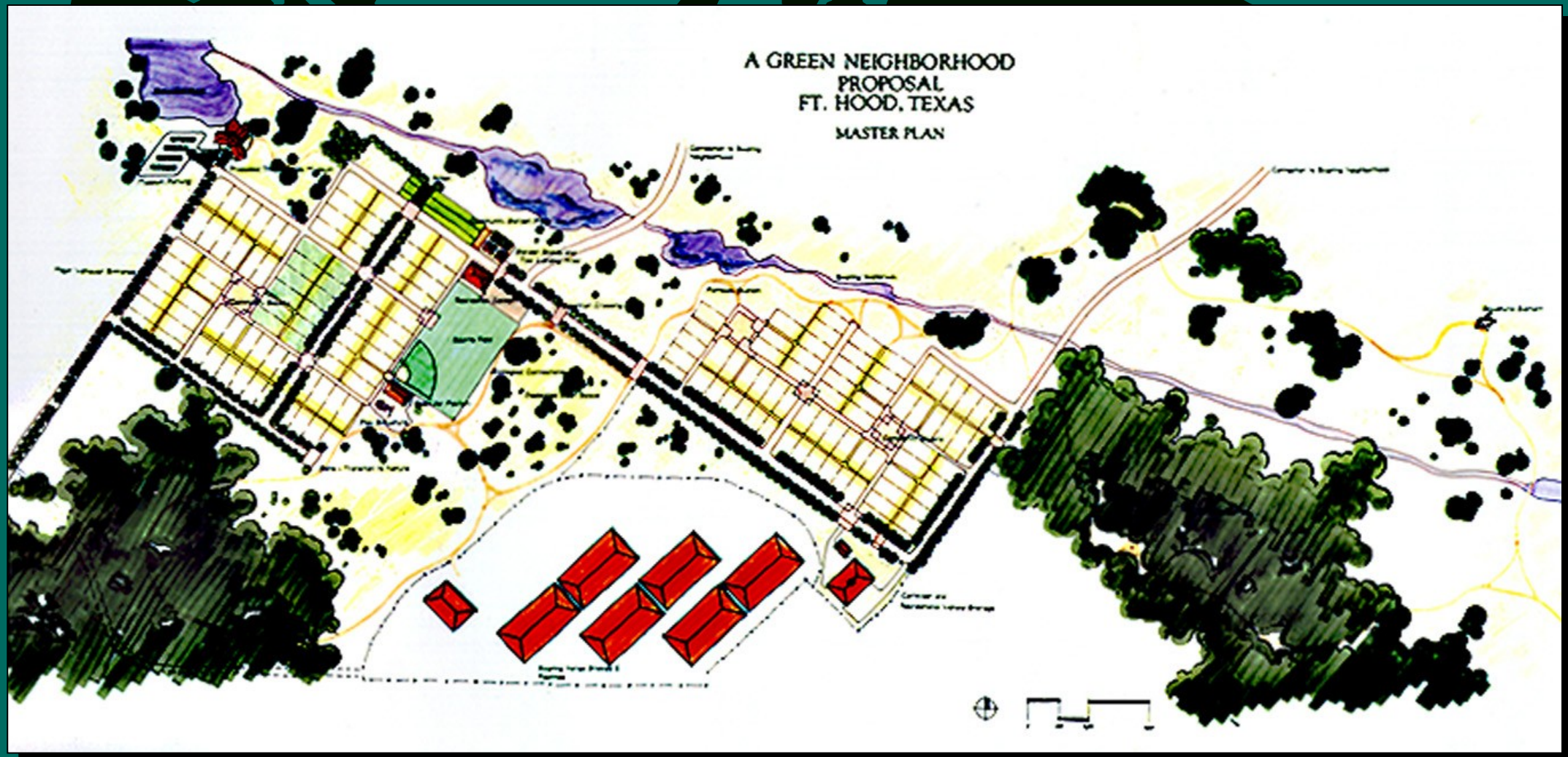
ft. hood texas

construction engineering research laboratory

Master Plans

- Resource conscious infrastructure
  - Integrate infrastructure with natural habitat
  - Native species inclusion
- Transportation design
  - Narrower street layout
    - slow traffic/reduce auto speeds
  - Provide for mass transportation
  - Design around pedestrian networks
- Neo Traditional approach
  - Allows for ecologically sensitive land use practices
  - Encourages community interaction
    - reduce crime potential
  - Enhanced wayfinding

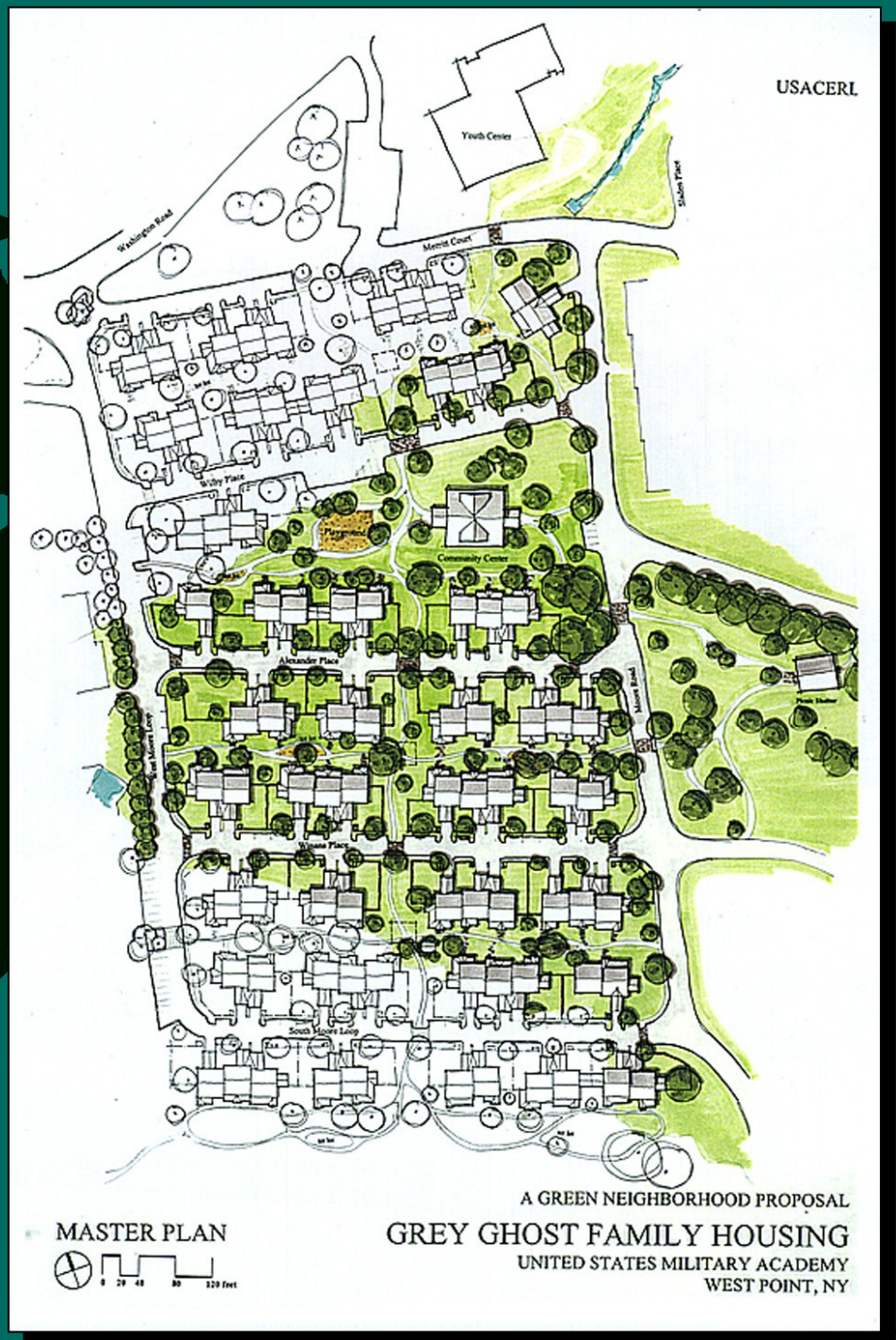
Ft Hood Neighborhood Plan



US Military Academy at West Point

Grey Ghost Family Housing Project

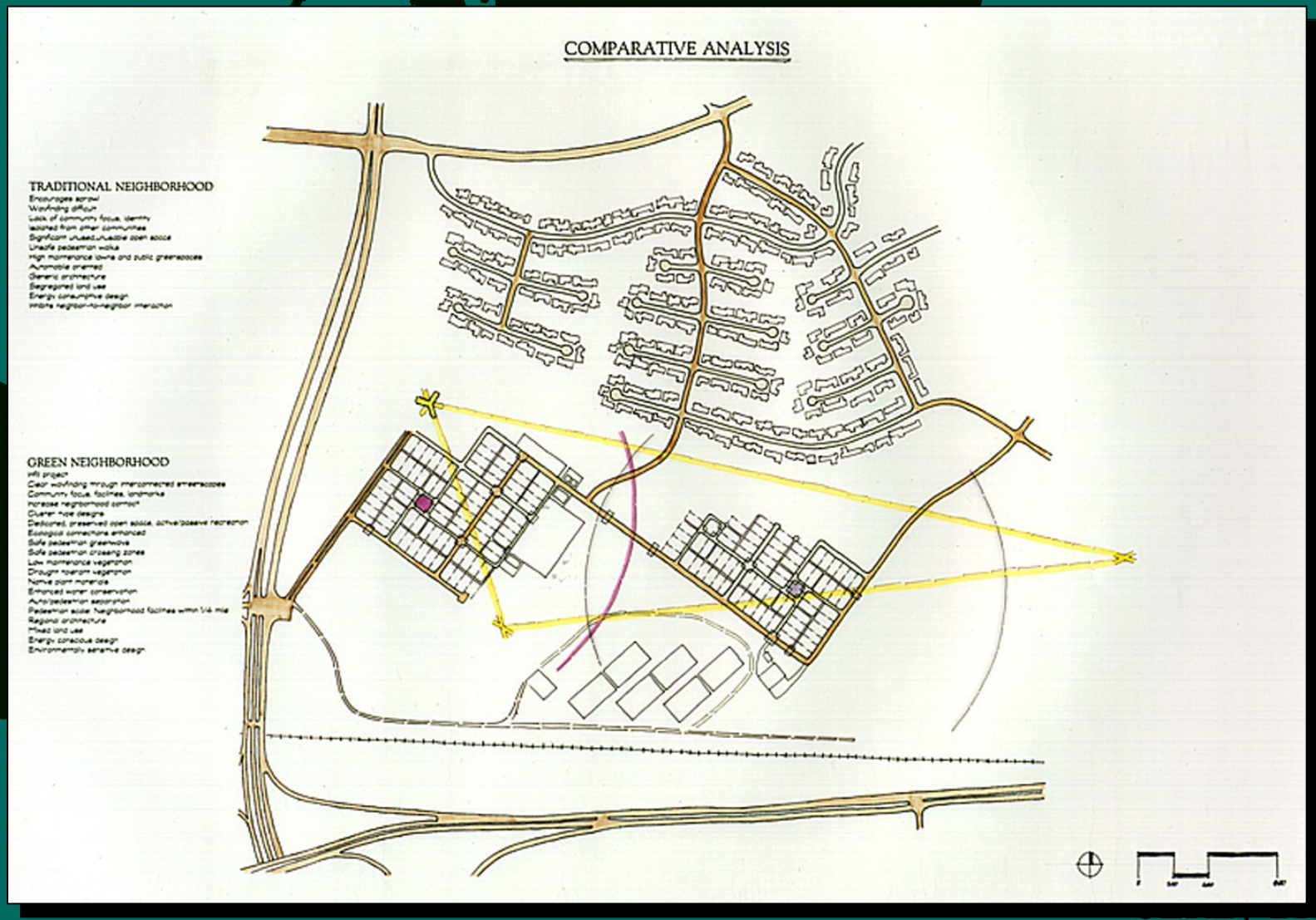
- existing site
- re-use existing infrastructure
- create pedestrian pathways
- community center
- off and on-street parking
- buffer views
- create neighborhood blocks



Cluster and Block Development

sprawl vs cluster development

- Collect unusable space
  - develop high-quality open space
- Cluster development patterns
  - walkable communities
  - sense of place
  - reduced development impact
- Neighborhood focus
  - neo traditional approach
- Recreational opportunities



Opportunity Costs

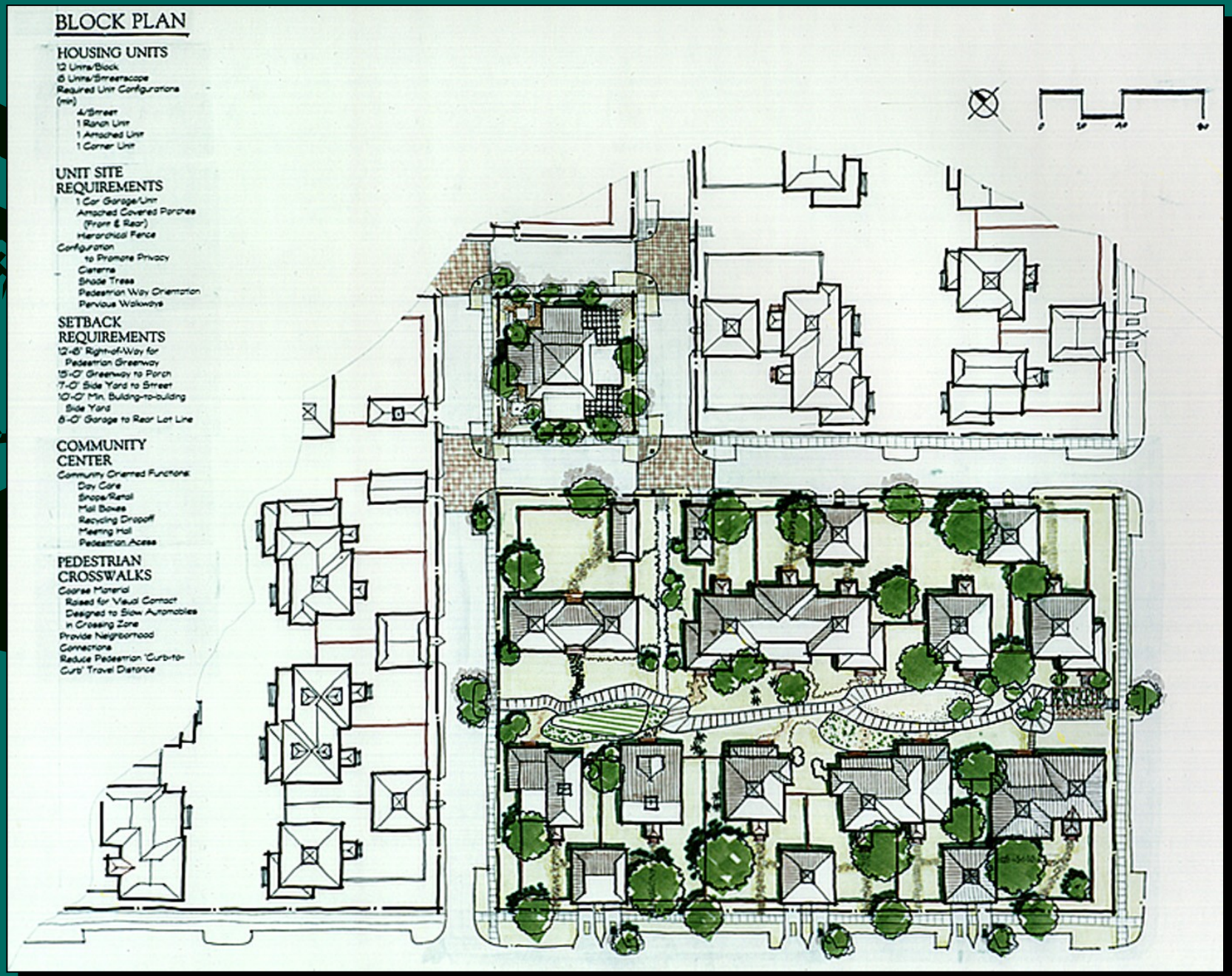
- A 1996 national home buyer's survey revealed that nearly three-fourths of all buyers would pay more to live in a community "where I can walk or bicycle everywhere"
- A study in northern Virginia showed that fringe residential development costs more to serve than it generates in tax revenue
  - farms generate $1 in revenue for every $0.21 of services needed
  - fringe development costs $1.20 in services for every $1 they generate.
    - the average annual revenue shortfall
      - $2200 per dwelling for a low-density development that of a high-density development
      - $700 per dwelling a high-density development

(American Farmland Trust, 1986).

Block Plans

- Enhanced Quality of Life
  - increased sense of community
  - community / recreational centers
  - greenway access
  - neighborhood garden plots
- The Neighborhood
  - limited area
  - mixed dwelling units
  - access to neighborhood centers
  - balanced mix of activities
- The Street
  - building block of neighborhood
  - promote pedestrian use by design
- The Residence
  - cluster type design to promote open space
  - energy efficiency requirements
  - layout maximizes usable spaces - increased efficiency

Ft Hood Block Plan



Housing Prototypes

- Vernacular architecture
  - site specific design
- Modular construction techniques
  - structural insulated panels
  - reduced costs
  - increased energy efficiency
- Materials
  - low impact (‘embodied energy’)
  - high recycled content
  - safe, non-toxic
- Improved envelope/fenestration
  - design for daylighting
  - increased insulation
  - natural ventilation/indoor air quality
  - high albedo materials
- Layout
  - increases efficiency
  - promotes privacy aspects

Sustainable Materials

attributes

- Low Lifecycle Impacts
- Low Embodied Energy
- High Recyclable and Recycled Content
- Low Toxicity
- Low Maintenance Requirements/Durability
- Uses Renewable Resources
- Uses Local Resources
- Is a Reusable Resource
- Uses Sustainable Manufacturing /Harvesting Practices

CO2 balanced - no net addition of CO2 from material

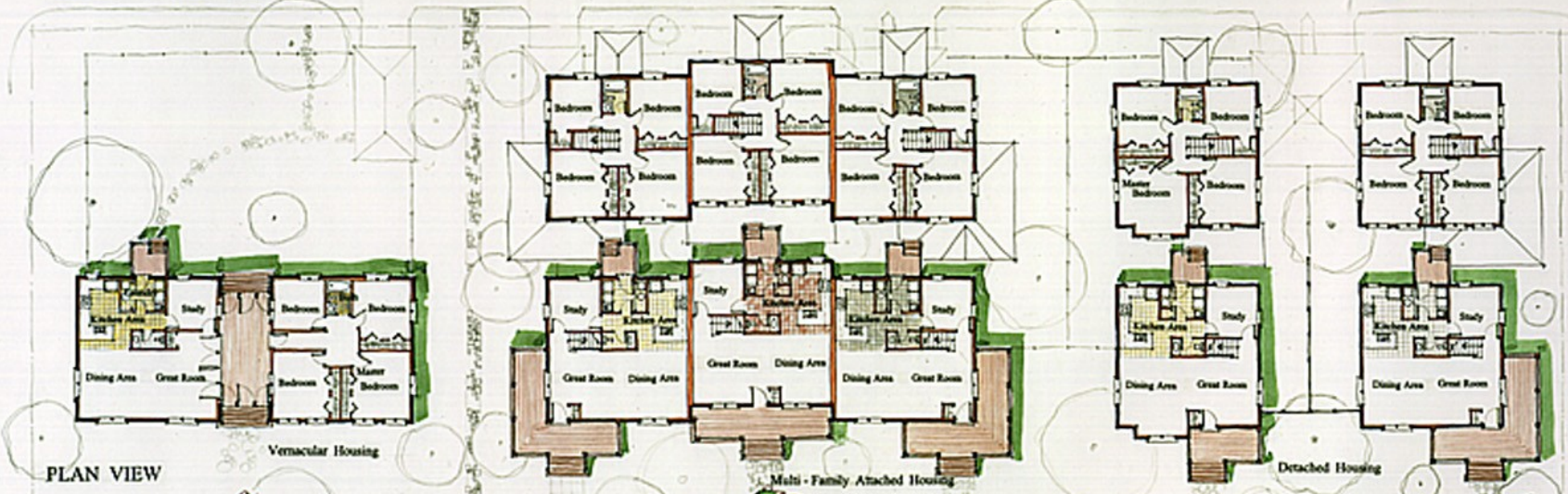
A GREEN NEIGHBORHOOD PROPOSAL

FT. HOOD, TEXAS

USACERL / University of Illinois
collaborative design

HOUSING PROTOTYPES

GREENWAY ELEVATION



PLAN VIEW

STREET ELEVATION

Ft Hood Housing

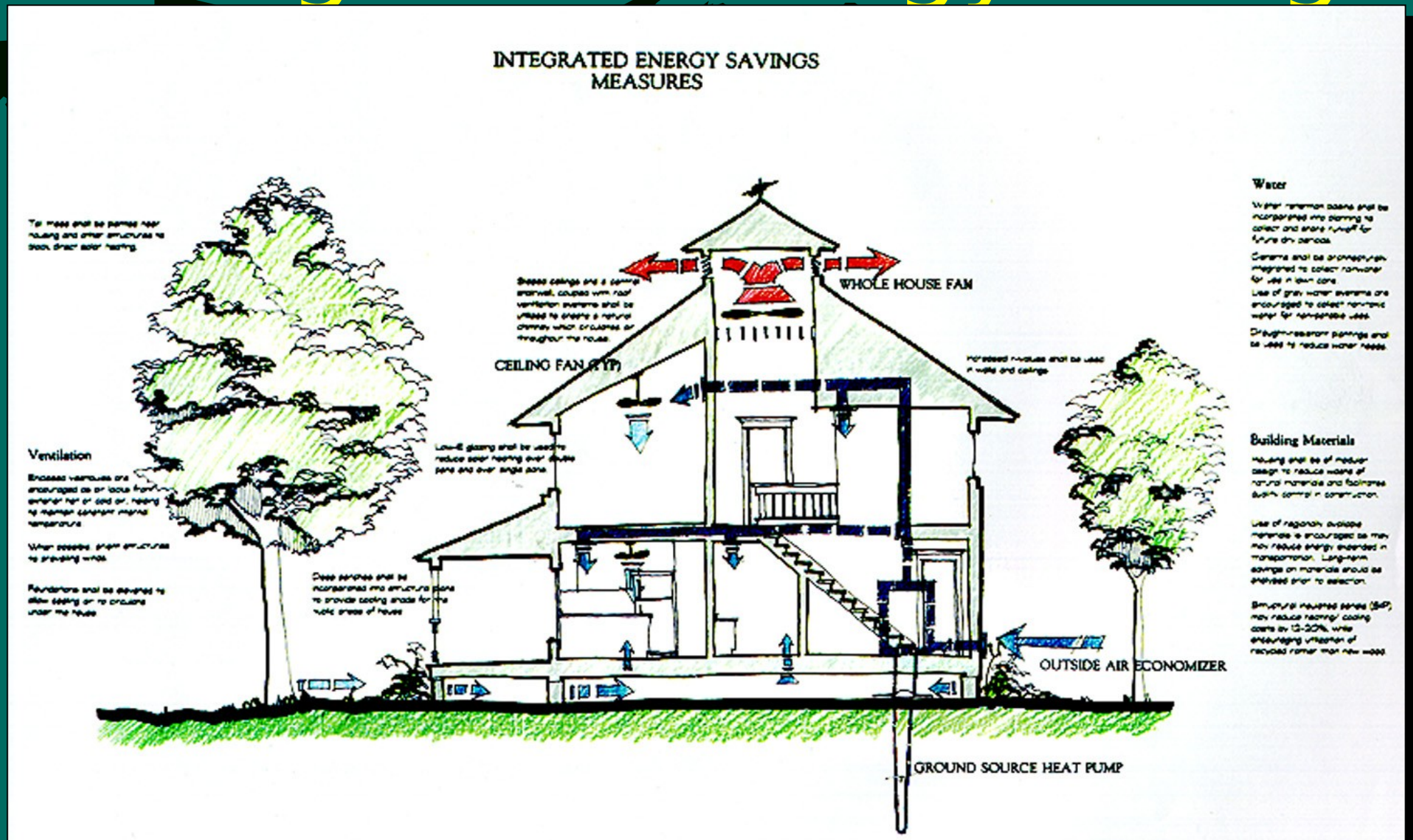
CERL / BRC

Integrated Energy Savings

- Advanced technologies
  - high efficiency
  - holistic ventilation system
  - appropriate use of renewable sources
  - improved natural circulation
- Efficient appliances
  - EPA refrigerator program
  - lighting
- Storm water engineering
  - cisterns
  - overland collection system
- Material selection
  - high albedo
  - thermal qualities
  - low maintenance
- Construction techniques
  - decrease infiltration

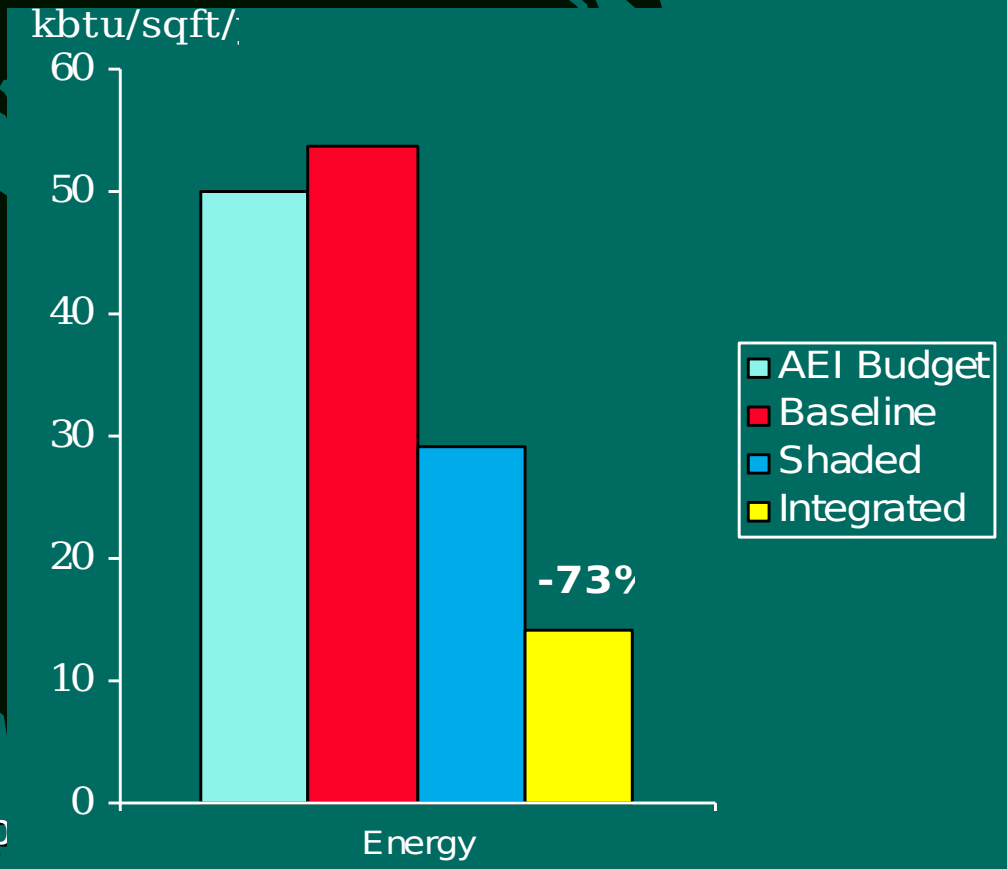
The life cycle energy consumption of a typical new house is 2,525 barrels of oil, only 6.3% of which is embodied energy, versus 927 barrels for the same house with energy efficient design.
(Blanchard and Reppe, http://www.umich.edu/~nppcpub/research/lcahome)

Integrated Energy Design



Energy Analysis

- Baseline energy analysis
  - Conventional hvac system
  - Standard construction techniques
  - Standard landscaping practices
- Integrated energy savings
  - Advanced hvac technologies
  - Appropriate technology
  - Renewable resources
  - Holistic, natural ventilation
  - Vegetative cooling techniques
- Findings
  - Over 70% reduction in energy consumption for the Integrated app



Cost Analysis

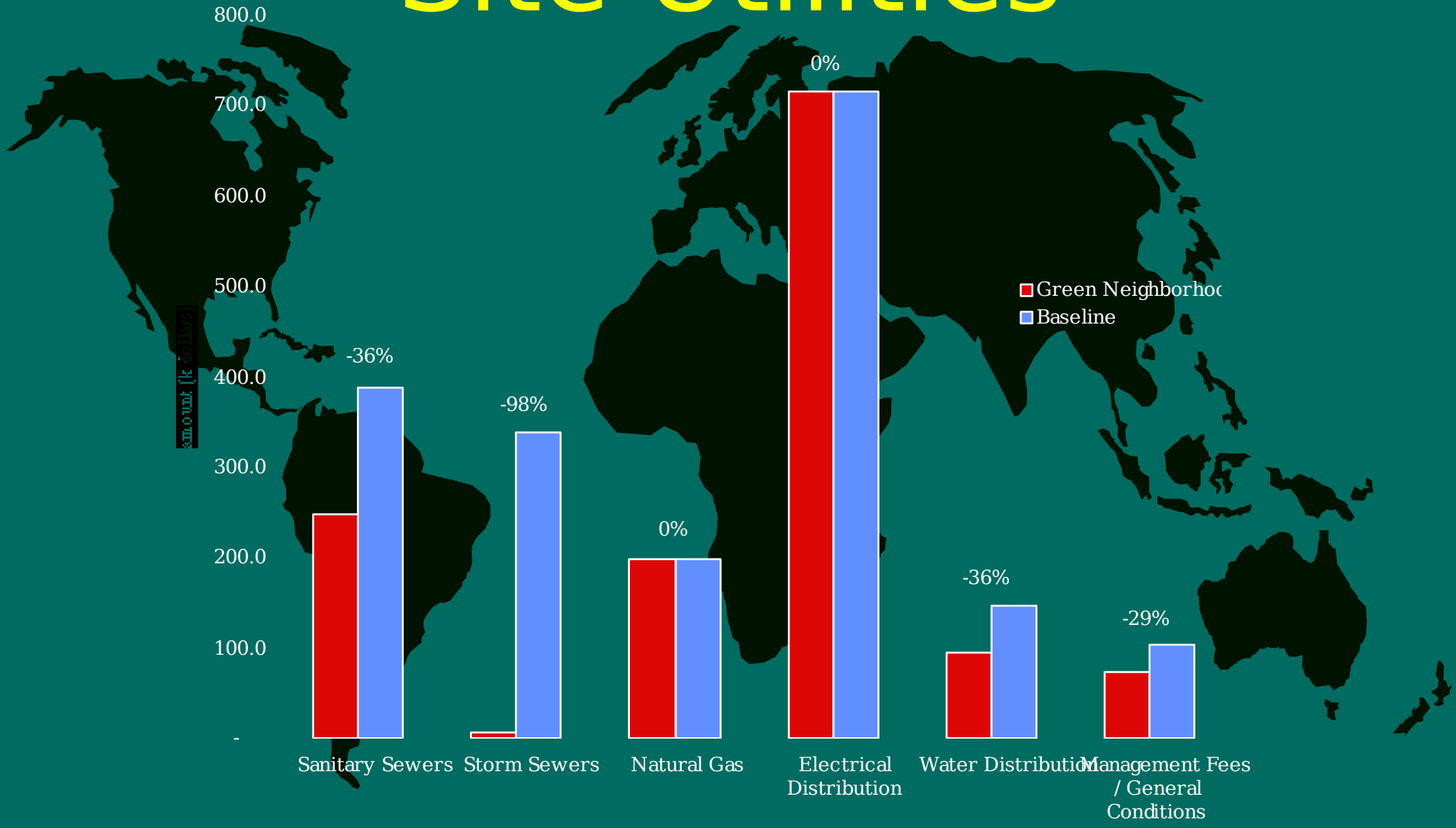
major components

- Design Fees
- Site Utilities
- Recreational Areas
- Landscaping
- Site Development
- Housing Unit Costs

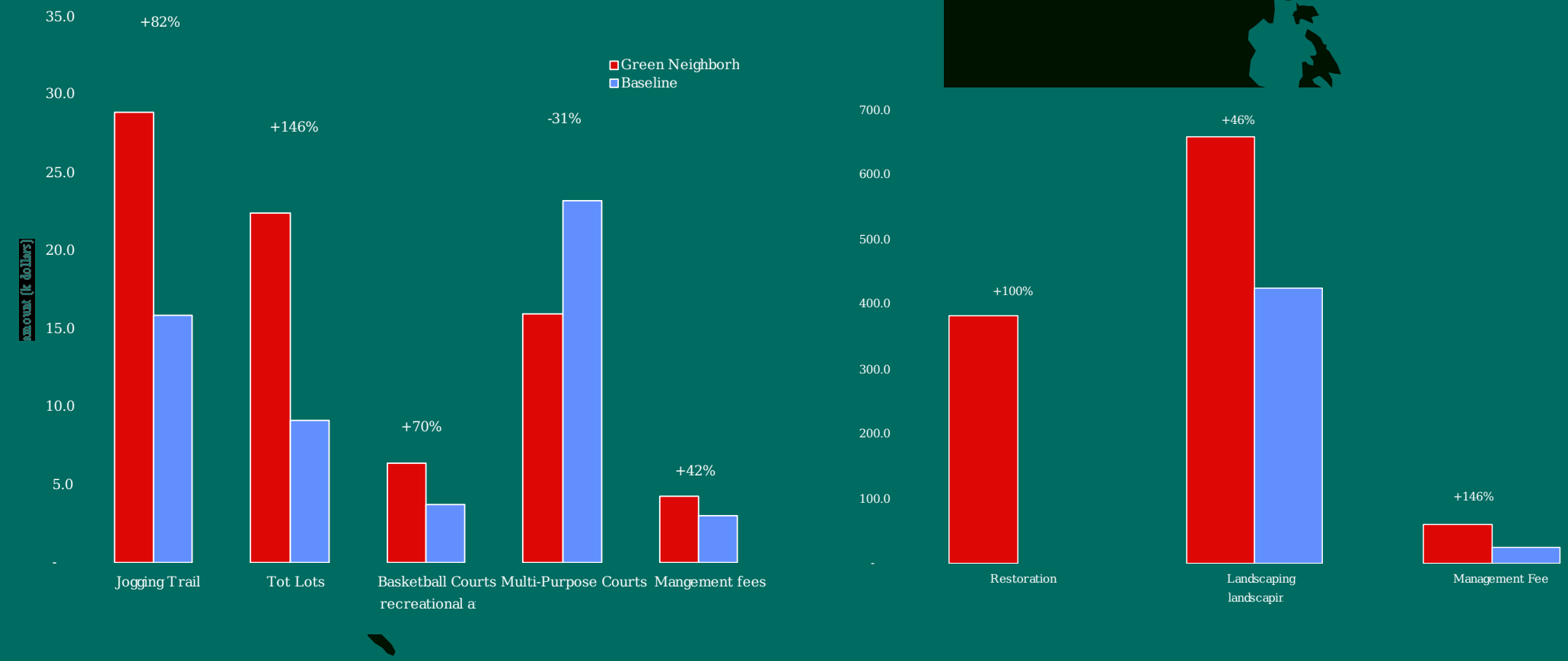
Design Fees

450.0
400.0
350.0
300.0
250.0
200.0
150.0
100.0
50.0
-
amount (k dollars)
+17%
+18%
+150%
+11%
0%
0%
+33%
Green Neighborhood
Baseline
Architect/Interior Design Fees
Structural Design Fees
Civil Design Fees
Landscaping Design Fees
Traffic Study
CADD Drawings
Management Fees/Genl Cond.
trade

Site Utilities

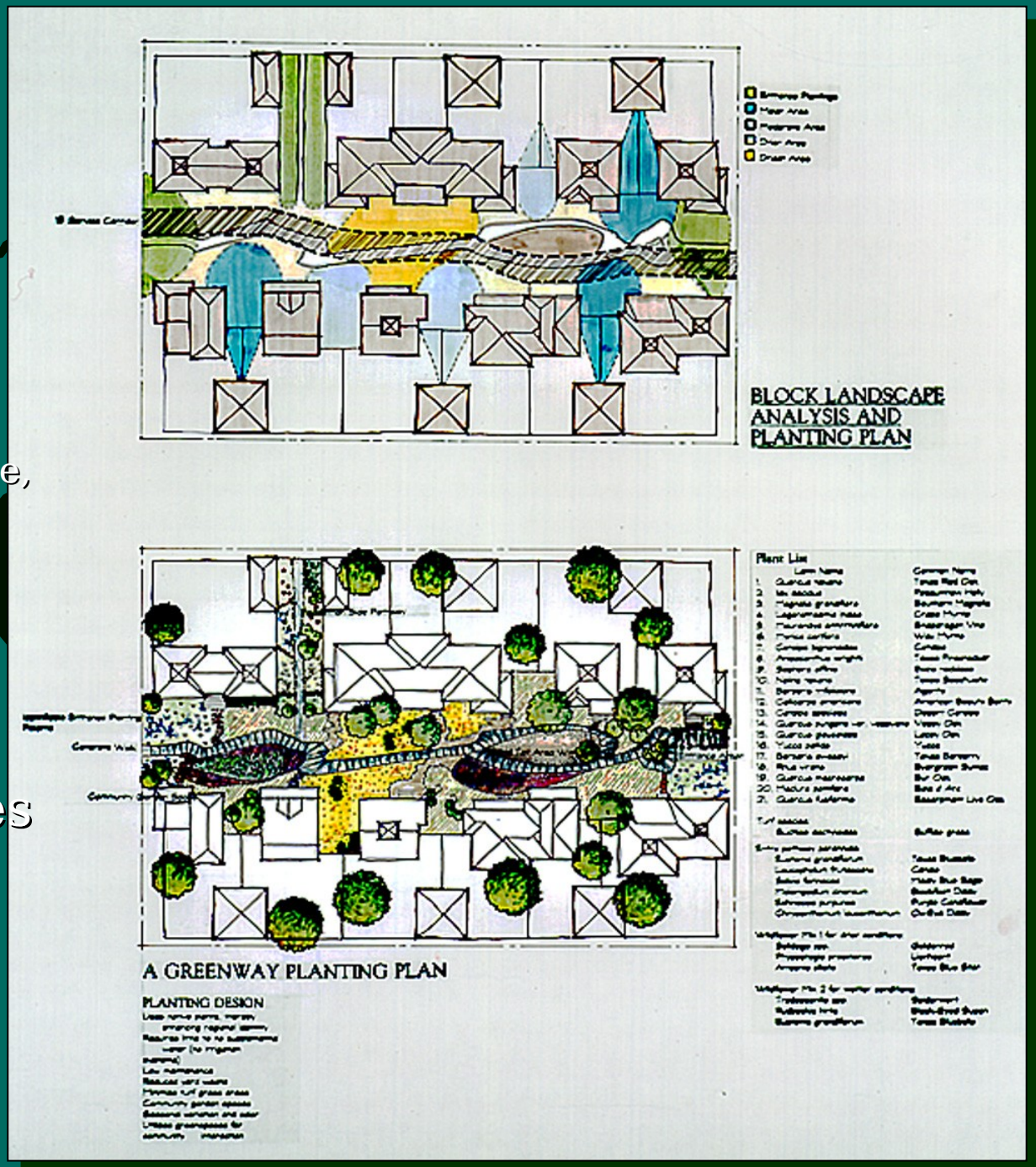


Recreational Areas and Landscaping

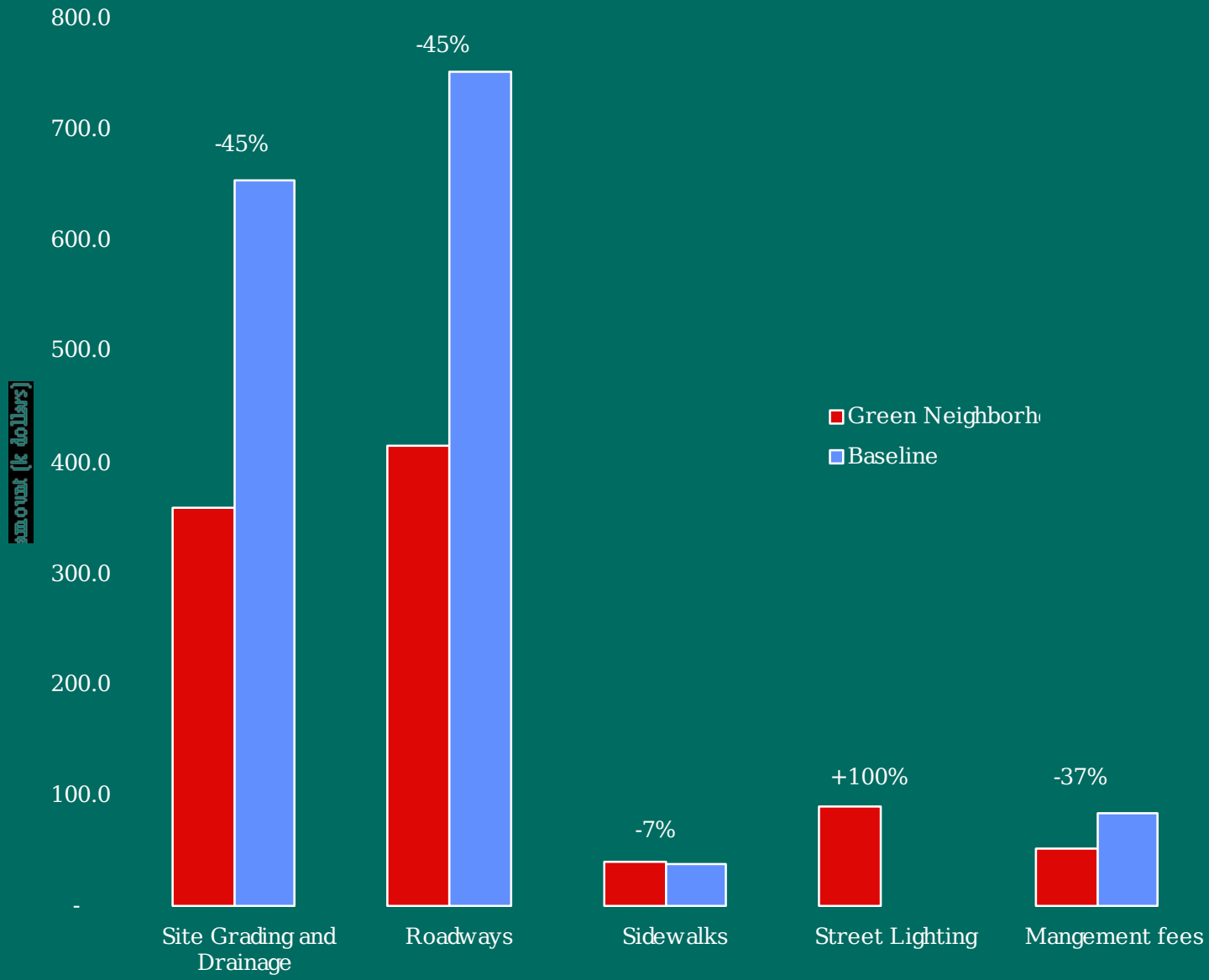


Landscape Design

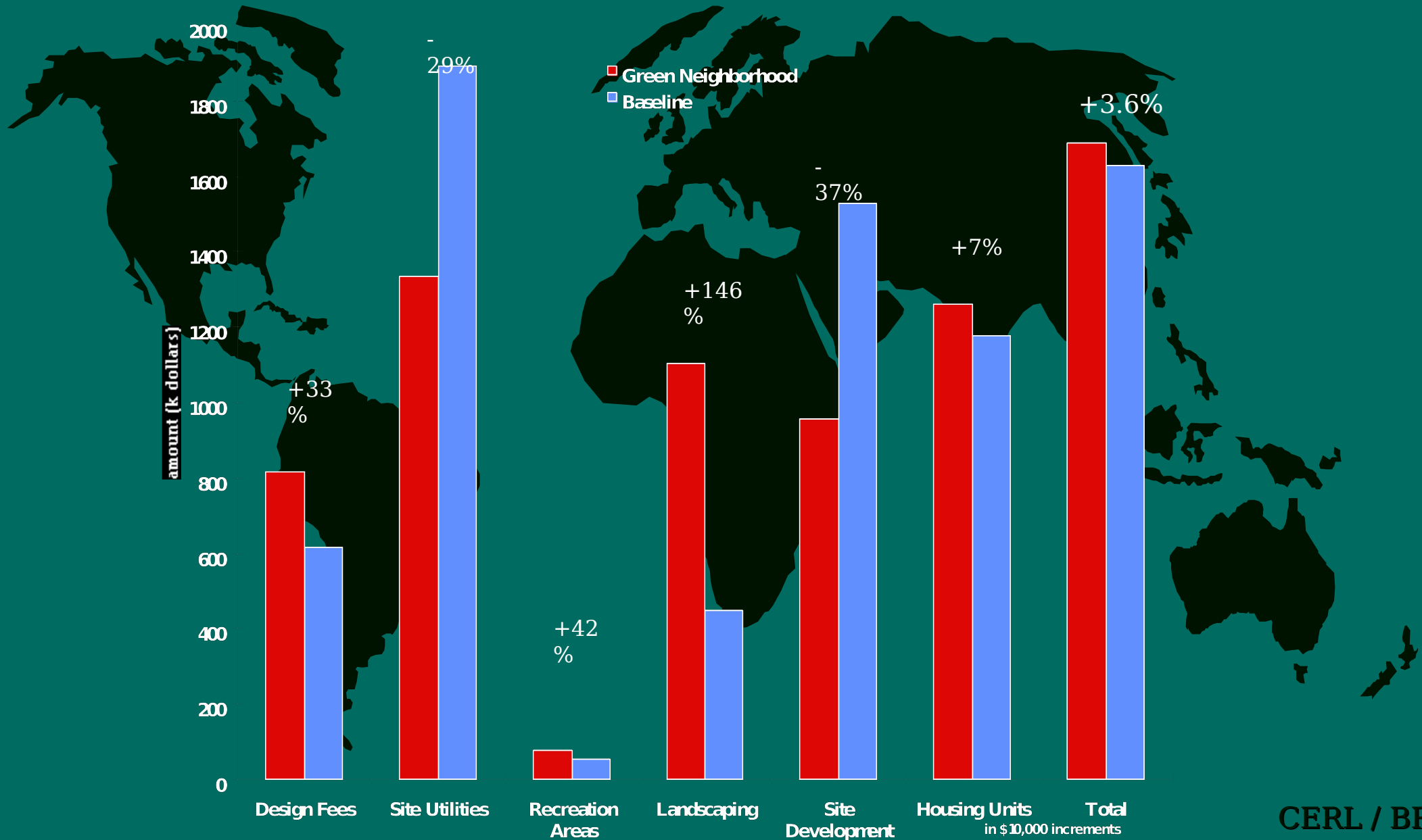
- Native, sustainable landscaping
  - low water, high drought tolerance, low maintenance
  - preserve the natural grades
  - low maintenance
- Storm water collection system
- Vegetative shading devices
- Reforestation of open space



Site Development

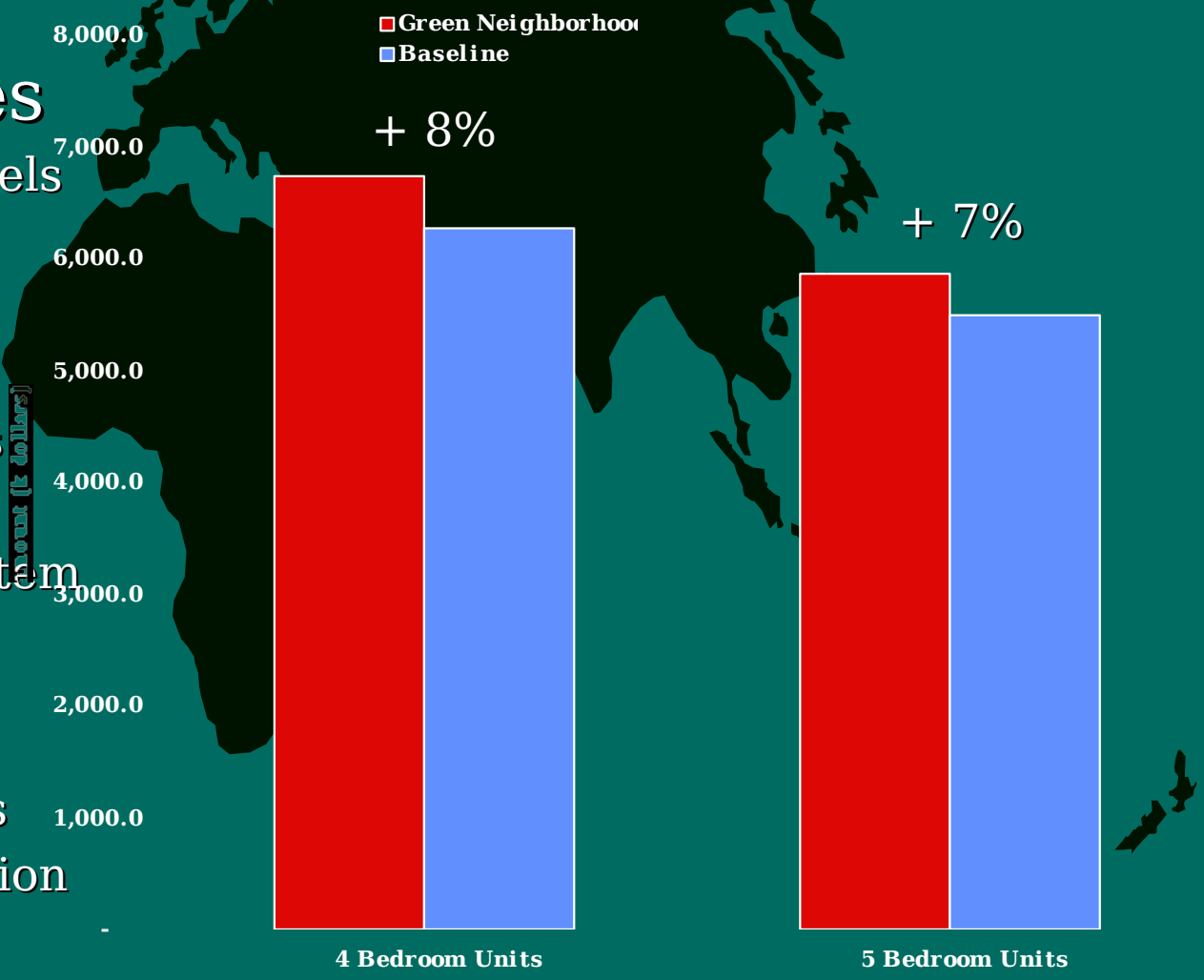


Total Costs


Green Neighborhood
Baseline
amount (k dollars)
2000
1800
1600
1400
1200
1000
800
600
400
200
0
+33 %
- 29%
+42 %
+146 %
- 37%
+7%
+3.6%
Design Fees
Site Utilities
Recreation Areas
Landscaping
Site Development
Housing Units
Total
in $10,000 increments

Housing Units

- Cost Increases
  - stressed skin panels
  - windows
  - roofing material
  - exterior finish
  - plumbing fixtures
  - kitchen area
  - efficient hvac system
- Cost Savings
  - carpentry labor
  - interior partitions
  - additional insulation
  - exterior flatwork



A USACERL-UIUC
Collaborative Effort
Under the Direction of
Larry Lister, PI &
Professor Robert L Selby, AIA

A GREEN NEIGHBORHOOD PROPOSAL FT. HOOD, TEXAS

MODULAR DESIGN ELEMENTS

Jeffrey Adams, Jon Bosler
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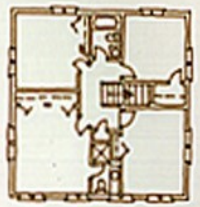
Basic Module

The basic module is a 29'x29' square footprint. Layout of the living floor is generally unaltered between houses. Bathrooms are converted to hallways in single story configurations. Mechanical closet may be located as indicated here, or in the rear vestibule, with additional space used for the kitchen.

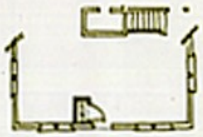
The sleeping floor, composed of four 14.5'x14.5' squares can be assembled as needed to create 2-, 3-, or 4-bedrooms. A second bath may be included, as indicated here. Otherwise, this space may serve as closets and additional bedroom footage.



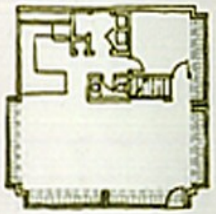
Attachments

Attachments to the basic module may include

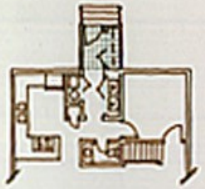
A 2'-7'x3' coat closet may be located inside the front entrance door



14'x2'-3' bays may be used to expand living or sleeping areas as needed.



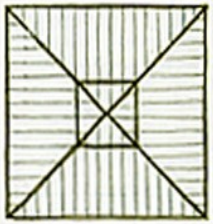
A 7'x7' rear enclosed vestibule may contain a mechanical or coat closet, and which supports a clerestory within the roof structure.

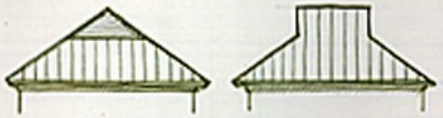


Roof
Roof Ventilation

Roof styles include hips, or hip-and-gables - all at an 8/12 pitch, with venting at the uppermost peak, to allow whole-house ventilation. Overhangs are 24" deep.

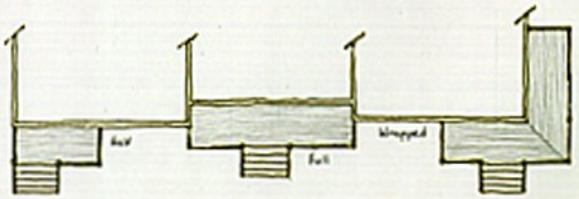
Belvederes, vented cupolas, and gable vents aid in creating a natural chimney effect for whole-house ventilation

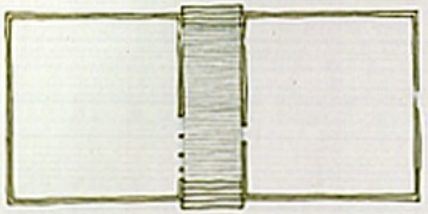




Porches

All house plans incorporate porches which are equal in depth to 1/4 module, or 7'-3". They may extend the full width of the house, 1/2 of the width, or may wrap around one corner of the house. All porches are to have railings.

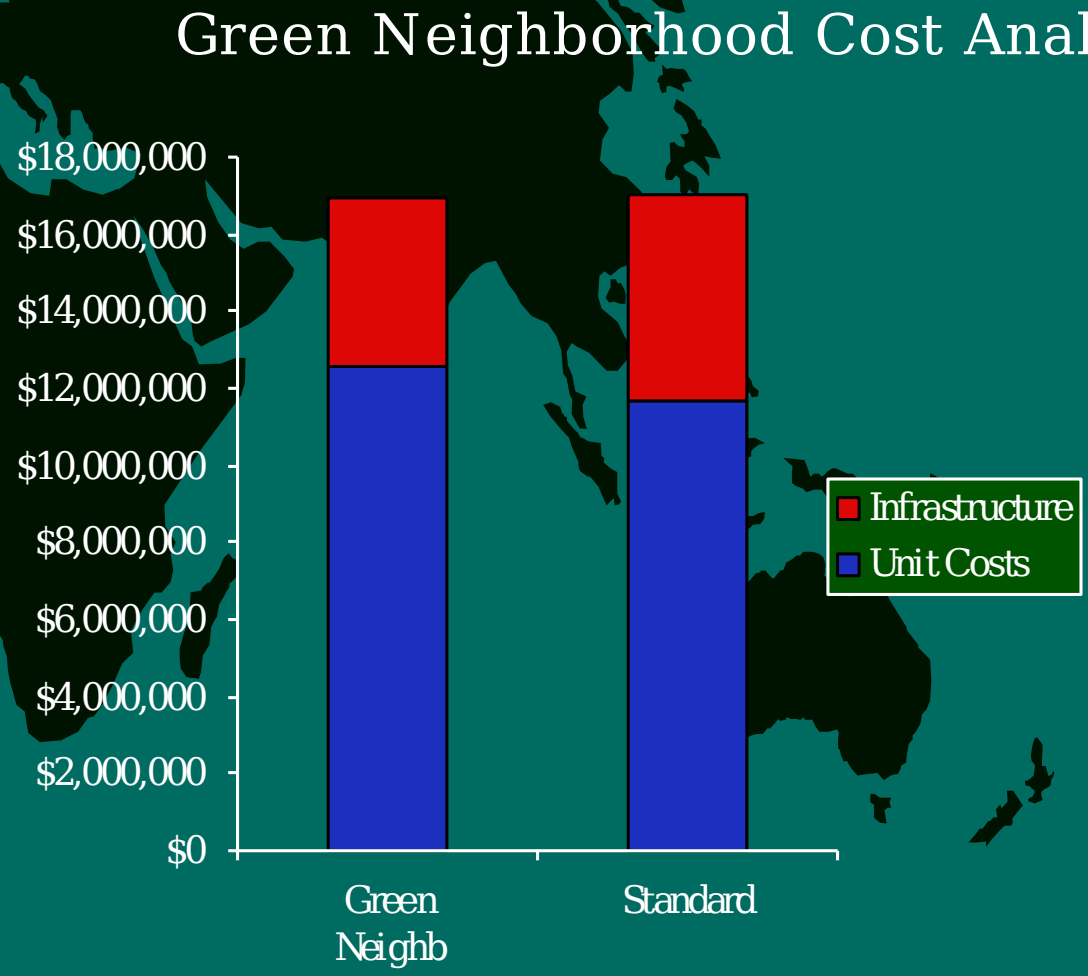




Modular Design Elements

Cost vs. Standard Practice

- Design - increased cost at conceptual phases
- Construction
  - infrastructure: 20% reduction
  - buildings: 10% increase
  - infrastructure savings have financed better buildings
- Operation (Energy) - reduced
- Maintenance - reduced



Conclusions

- A concern for the environment has spawned research that is beginning to outline the benefits of conserving and restoring our natural landscape. Sustainability challenges the guidelines and processes of existing housing development. The existing substandard housing cycle is developed from guidelines that sacrifice the long range benefits of effective planning, design and construction for the short range benefits of front-end cost saving measures.
- The hypothesis that the front-end costs of the existing housing development paradigm is significantly lower than neo-traditional, ecologically sensitive planning is refuted through this cost comparison analysis. Although front-end design and planning costs raise the project cost slightly higher than the prevailing 'sprawl' cost, the long range energy saving benefits are projected to save significantly in the future.
- This cost analysis outlines the importance of design as a tool for providing high quality, well constructed housing developments at reasonable costs.

GREENWAY